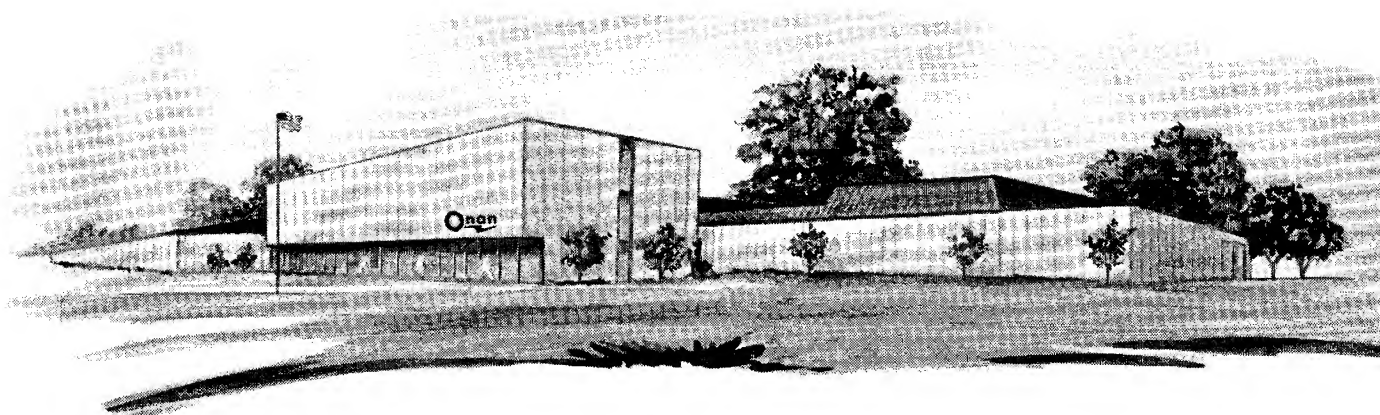


T-009

technical bulletin

SELECTING ONAN ELECTRIC GENERATING SETS FOR ELECTRIC MOTOR LOADS



ONAN

1400 73RD AVENUE N.E. • MINNEAPOLIS, MINNESOTA 55432

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INTRODUCTION

Due to initial cost of generator sets, the installation, and other equipment involved, it is extremely important to initially select the correct generator set. The information in this bulletin should simplify generator set selection and eliminate common errors in selection. The practical and theoretical information combined with practical experience of Onan distributors and dealers will enable the best selection of an Onan generator set for your application.

The information in this bulletin was compiled and is based on Onan designed generator sets only. Although the information may apply to other manufacturers' generator sets, we assume no responsibility for their application using the data in this bulletin.

When determining generator set size, consider the fact that electrical usage has a growth which doubles about every ten years. Select a generator set of adequate size for your anticipated future needs.

All information, illustrations and specifications contained in this manual are based on the latest product information available at the time of publication. Onan reserves the right to make changes at any time without notice.

Part I of the bulletin covers the detailed listing of motors, their power factor, starting and running kW's and kVA's, and Onan generator set ratings. Tables, sample selection problems, and a form for compiling data for the actual generator set selection are included.

Part II covers load applications when considering generator set selection. Phase unbalance and reduced voltage motor starting are just some of the subjects discussed.

TABLE OF CONTENTS

PART I - SELECTION OF GENERATOR SET	2
Description of Onan Motor Starting Form	3
Step-By-Step Procedure Using Example Problems	4
Examples Shown on Motor Starting Form	5
 PART II - THEORY AND PROBLEMS ASSOCIATED	
WITH COMMON LOAD APPLICATIONS	14
Code Letter and Design Letter	15
Typical Motor Starting Systems	16
Full Voltage Motor Starting	16
Autotransformer Motor Starting, Open Transition	16
Autotransformer Motor Starting, Closed Transition	17
Reactor Motor Starting, Closed Transition	17
Resistor Motor Starting, Closed Transition	18
Star-Delta Motor Starting, Open Transition	18
Part Winding Motor Starting, Closed Transition	19
Wound Rotor Motor Starting	19
Synchronous Motors	20
Reduced Voltage Motor Starting	21
X-Ray Applications	23
Allowable Single and Three-Phase Unbalance	24

PART I

SELECTION OF GENERATOR SET

DESCRIPTION OF ONAN MOTOR STARTING FORM

MOTOR STARTING FORM

MOTOR INFORMATION FROM MOTOR NAMEPLATE				REDUCED VOLTAGE MOTOR STARTING		MOTOR STARTING LOAD (Locked Rotor)		MOTOR RUNNING LOAD			ACCUMULATED LOAD PLUS NEXT MOTOR STARTED		ACCUMULATED LOAD		NOTES: NAME OF LOAD, VOLTAGE DIP, ETC.
1	2	3	4	5		6	PF	7	8	9	10	11	12	13	
HP	Code	φ	Volts	Tap	Mult.	LRkVA		LRkW	kVA	kW	Max. kVA	Max. kW	Cont. kVA	Cont. kW	
										Add 6 to 12	Add 7 to 13	Add 8 to 12	Add 9 to 13		
1															
2															
3															

The following numbered paragraphs explain each of the first nine columns on the motor starting form above (above is reduced from actual form).

1. MOTOR HORSEPOWER (HP)

The National Electrical Manufacturers Association (NEMA) lists standard horsepower ratings for induction motors. Except for certain motors, a standard horsepower rating found on the motor's nameplate will correspond with the data on Page 4.

2. MOTOR CODE LETTER (CODE)

A code letter can be found on the nameplate of most alternating current motors. The letter is a code for starting kVA per horsepower. Starting kVA per horsepower has been compiled in Table 2 (next page).

Don't confuse the code letter with the design letter. See CODE LETTER AND DESIGN LETTER in PART II.

3. PHASE (φ)

Both single phase and three phase motors are available in ratings up to 10 horsepower. However, motors 7-1/2 horsepower and larger are usually three phase.

4. VOLTAGE

When listing the voltage, list the motor nameplate voltage and not the generator voltage.

5. REDUCED VOLTAGE MOTOR STARTING

List the amount of voltage reduction in percent (%) tap. Use a 1.0 when across the line starting is used. An explanation of reduced voltage motor starting and examples are given in Part II of this bulletin.

6. kVA STARTING (LRkVA)

Starting kVA required by a motor is found in Table 2 under the appropriate code letter column. For any motor of given horsepower and code letter,

the locked rotor kVA draw is the same regardless of the phase, speed and voltage rating on the motor nameplate.

7. kW STARTING (LRkW)

Locked rotor kW is determined by multiplying the locked rotor kVA by the motor locked rotor power factor (PF). The typical power factor for motors is listed in Table 2.

8. MOTOR RUNNING (kVA)

The kVA for a running motor is the apparent power required by the motor at rated speed and load (Table 2).

9. MOTOR RUNNING (kW)

The kW for a running motor is the real power required by the motor at rated speed and load (Table 2).

TABLE 1. REDUCED VOLTAGE MOTOR STARTING

STARTING METHOD	TAP	MULTIPLIER
Full Voltage	100	1.0
Autotransformer	80	0.64
	65	0.42
	50	0.25
Series Reactor or Resistor	80	0.80
	65	0.65
	50	0.50
Star Delta	33*	0.33*
Part Winding	66*	0.66*
Wound Rotor	**	**

* No standard values of kVA and torque are available. These are typical values and can be used only if the motor will reach run speed before transfer to run windings. Please contact motor supplier for information.

** See *Wound Motor of TYPICAL MOTOR STARTING SYSTEMS* in Part II.

STEP-BY-STEP PROCEDURE USING EXAMPLE PROBLEMS

The following step-by-step procedure shows how to fill out the motor starting form.

1. On the first line under "ACCUMULATED LOAD" (columns 12 and 13), list all the lighting and heater loads which are on the circuit before the motors are started. If no lighting or heater loads are on the circuit, list on line "1" the first motor started (as shown in Step 3).
2. List all other loads in the order they will be applied to the generator set. For the smallest generator set, the larger motors should be started first whenever possible. In automatic start applications, list the larger motors last.
3. In columns 1, 2, 3 and 4, enter the horsepower, code letter, phase and voltage of each motor. List the motors in the sequence they are started—use a separate line for each motor.
4. Decide on the generator set voltage needed (480-volt generator sets are used in samples). The different voltage combinations, the standard motor voltages, and generator set voltages are listed in Table 2A and 2B.
Obtain the locked rotor kVA under the proper code letter for each motor. Enter this value in column 6 if across-line starting (examples 1, 2 and 5). When starting blocks of motors, total all in block and enter on a single line. See example 4.
(287 LRkVA + 860 LRkVA = 1147 LRkVA)
5. For a motor utilizing a reduced voltage starter, enter the tap and multiplier in column 5. Enter the product of locked rotor kVA (from Table 2) times the multiplier in column 6. See example 3.
(860 LRkVA x 0.42 = 361.2 LRkVA)
6. Multiply the locked rotor kVA (column 6) times the locked rotor power factor (PF) and enter this value in column 7—for examples 1, 2 and 3 only. For an application as example 4, multiply the locked rotor kVA times the locked rotor power factor for each motor. Add these two figures and enter in column 7. (287 LRkVA x 0.36 PF) + (860 LRkVA x 0.28 PF) = 103 LRkW + 241 LRkW = 344 LRkW (enter in column 7).
7. Obtain the running kVA and running kW for each motor from Table 2 when the actual value is unknown, and enter these values in columns 8 and 9 (examples 1, 2, 3 and 5). For example 4, add the running kVA and running kW of each motor and enter the totals in columns 8 and 9: 49 kVA + 140 kVA = 189 kVA, enter in column 8; 41 kW + 123 kW = 164 kW, enter in column 9.

DETERMINING MAXIMUM AND CONTINUOUS LOAD

The generator set selected must have the capability of supplying the maximum load during the starting for each motor and continuous load when the motors are running. Progressive totals of the accumulated load and the incoming motor's starting load will show the maximum kVA and kW demand during the time each motor is starting. Progressive totals of the accumulated load and the incoming motor's running load will show the continuous kVA and kW demand after each motor is running.

8. Start with the first motor; add the kVA from column 6 to the kVA from column 12 of the line above. Enter this total in column 10 (example 1, 860 kVA + 12 kVA = 872 kVA).
9. Start with the first motor; add the kW from column 7 to the kW from column 13 of the line above. Enter this total in column 11 (example 1, 241 kW + 12 kW = 253 kW).
10. Add the kVA from column 8 to the kVA from column 12 of the line above. Enter this total in column 12 (example 1, 140 kVA + 12 kVA = 152 kVA).
11. Add the kW from column 9 to the kW from column 13 of the line above. Enter this total in column 13 (example 1, 123 kW + 12 kW = 135 kW).
12. Repeat Steps 8 through 11 for each motor in turn. This completes the calculations.
13. Refer to Tables 4, 5, 6, 7, or 8. Select the table describing units of the phase and frequency used in the calculation. In the table, the columns which give the generator set ratings are numbered to correspond with the column number in the motor starting form. Circle the number which is the limiting factor in reducing the generator size. Select the smallest generator set which has the maximum kVA and kW capabilities, and continuous kVA and kW ratings equal to or greater than the circled numbers on the compilation form.

Consider additional capacity for future requirements when making the selection.

EXAMPLES

- #1. Largest Motor First.
 #2. Largest Motor Last.
 #3. Reduced Voltage Motor Starting.
 #4. Simultaneous Starting of all Motors.
 #5. Sewage Lift Pump (low inertia).

Examples demonstrate how different applications with same HP motors can vary generator set selection.
 Circle the value which prevents reducing the generator set to the next size.

CAUTION

A time delay, approximately 10 seconds minimum, is required between starting large motors.

MOTOR INFORMATION FROM MOTOR NAMEPLATE										REDUCED VOLTAGE MOTOR STARTING			MOTOR STARTING LOAD (Locked Rotor)				MOTOR RUNNING LOAD			ACCUMULATED LOAD PLUS NEXT MOTOR STARTED				ACCUMULATED LOAD			NOTES: NAME OF LOAD, VOLTAGE DIP, ETC.
1	2	3	4	5	6		7	8	9	10		11	12	13													
HP	Code	φ	Volts	Tap	Mult.	L RkVA	PF	L RkW	kVA	kW	Max. kVA Add 6 to 12	Max. kW Add 7 to 13	Cont. kVA Add 8 to 12	Cont. kW Add 9 to 13													
1																											
2	150	F	3	460	1	860	0.28	241	140	123	872	253	152	135	12*	12*	Largest motor first, use only when on a manual starting system.										
3	50	F	3	460	1	287	0.36	103	49	41	439	238	201	176													
4						Recommend 250.0 DFM																					
5																											
6																											
7																											
8	50	F	3	460	1	287	0.36	103	49	41	299	115	61	53	12*	12*	Largest motor last—use on automatic demand systems.										
9	150	F	3	460	1	860	0.28	241	140	123	921	294	201	176			Must have 10 sec. time delay between start.										
10						Recommend 300.0 DFE																					
11																											
12																											
13																											
14	50	F	3	460	1.0	287	0.36	103	49	41	299	115	61	53	12*	12*	Reduced voltage starting, autotransformer.										
15	150	F	3	460	0.65	860	0.28	361.2	140	123	422	154	201	176													
16						Recommend 180.0 DFE																					

* Resistive (lighting) loads.



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CUSTOMER _____
ADDRESS _____
CITY _____ STATE _____ DATE _____
RECOMMENDED UNIT _____
VOLTAGE _____ PHASE _____
kW _____ kVA _____ PF _____
DERATINGS: Altitude _____
Fuel _____ Temperature _____
RATING FOR APPLICATION kW _____ kVA _____
MAXIMUM VOLTAGE DIP** _____

DEALER/DISTRIBUTOR _____
SALESMAN _____
ONAN REPRESENTATIVE _____

MOTOR INFORMATION FROM MOTOR NAMEPLATE					REDUCED VOLTAGE MOTOR STARTING			MOTOR STARTING LOAD (Locked Rotor)			MOTOR RUNNING LOAD		ACCUMULATED LOAD PLUS NEXT MOTOR STARTED			ACCUMULATED LOAD			NOTES: NAME OF LOAD, VOLTAGE DIP, ETC.
1	2	3	4	5	6	7	8	9	10	11	12	13	Cont. kW Add 9 to 13	Cont. kVA Add 8 to 12	Cont. kW Add 7 to 13	Cont. kVA Add 8 to 12	Cont. kW Add 9 to 13		
HP	Code	φ	Volts	Tap	Mult.	LRkVA	PF	LRkW	kVA	kW	Max. kVA Add 6 to 12	Max. kW Add 7 to 13							
1																			
2	50	F	3	460	1	1147		344	189	164	1159	356	201	176	12*	12*			All motors start at same time. Add all LRkVA and all LRkW.
3	150	F	3	460	1						1200	485	562	450					
4																			
5																			
6																			
7																			
8																			
9	150	F	3	460	1	860	-	-	140	123	872	-	152	135	12*	12*			Sewage lift application. Low inertia motors. Disregard max. kW columns 7 and 11.
10	150	F	3	460	1	860	-	-	140	123	1012	-	292	258					
11											1043		500	400					
12																			
13																			
14																			
15																			
16																			

880 63

** Voltage dip is often measured using peak reading (light beam) instruments or average reading (pen recorder) instruments, neither of which gives actual RMS voltage values. The RMS voltage dip, which is the only meaningful value, must be derived from test data by complex calculations. If the actual RMS voltage dip must be precisely known, your Onan distributor will be glad to help.

**TABLE 2. LOCKED ROTOR STARTING AND RUNNING MOTOR POWER REQUIREMENTS
(AVERAGE VALUES)**

HP	TYPICAL RUNNING AT 100% OF LOAD		PWR. FAC. STARTING 1 ϕ 3 ϕ	LOCKED ROTOR (STARTING) KVA - 1 ϕ OR 3 ϕ 50 OR 60 HERTZ																TYPICAL RUN AT 75% LOAD	
	KVA	KW		CODE LETTER																KVA	KW
				A	B	C	D	E	F	G	H	J	K	L	M	N	P	R			
12	40	25	80	58	38	44	49	55	62	69	77	87	98	100	123	138	154	172	195		
25	65	40	80	58	80	91	102	113	130	143	161	182	205	230	257	287	320	353	406		
33	72	45	80	58	105	120	135	152	170	190	213	240	270	304	340	378	423	473	536		
50	97	60	80	58	160	181	204	230	260	287	322	363	408	460	514	573	641	717	811	797	46
75	137	85	80	58	239	272	306	345	385	430	483	544	612	690	770	860	962	1074	1217	95	55
1	16	99	80	58	32	36	41	46	51	57	64	72	82	92	103	115	128	143	162	143	76
15	22	145	80	58	48	55	6	69	77	86	97	109	122	14	15	173	19	22	24	19	11
2	26	18	90	58	64	73	82	93	103	115	13	146	164	185	21	23	28	29	33	23	14
3	37	28	90	58	96	109	12	139	155	17	194	219	246	277	31	346	38	43	49	36	22
5	54	48	90	58	160	18	204	23	258	288	324	365	41	48	52	577	64	72	82	42	34
75	84	65	90	58	275	305	345	39	435	485	55	615	695	77	86	97	108	122	69	50	50
10	107	87	90	58	32	36	46	52	58	65	73	82	92	103	116	129	144	164	85	63	63
15	155	122	47	48	55	61	69	78	87	97	110	123	138	155	173	194	217	245	122	90	90
20	199	156	47	54	73	82	93	104	116	130	146	163	184	206	229	256	287	325	159	130	130
25	245	21	42	80	92	102	116	130	145	162	183	205	230	257	287	320	358	409	205	154	154
30	295	26	42	96	110	123	139	155	173	194	219	245	276	308	344	385	430	491	250	200	200
40	398	33	40	128	145	164	186	208	232	258	290	327	368	411	459	513	573	653	320	246	246
50	494	41	36	160	181	204	230	257	287	322	362	408	460	514	574	641	717	817	394	309	309
60	59	48	35	191	217	246	276	308	344	386	435	490	552	617	688	770	860	982	473	373	373
75	73	62	33	240	272	305	345	385	430	483	544	612	690	770	860	962	1075	1225	587	463	463
100	96	80	30	319	362	409	460	514	573	644	725	817	920	1028	1147	1281	1433	1635	744	613	613
125	120	105	29	400	452	510	575	642	717	805	905	1021	1150	1285	1433	1602	1790	2045	908	787	787
150	140	123	28	479	543	613	680	771	860	968	1087	1225	1380	1540	1720	1922	2150	2450	105	908	908
200	183	154	25	638	725	817	920	1030	1145	1287	1450	1633	1840	2055	2293	2563	2865	3270	141	1227	1227
250	223	202	23	798	906	1021	1150	1285	1435	1610	1810	2042	2300	2568	2866	3205	3585	4055	170	151	151
300	280	246	22	957	1086	1225	1380	1540	1720	1930	2175	2450	2760	3085	3440	3845	4300	4870	210	182	182
350	323	287	21	1116	1268	1430	1610	1800	2010	2255	2535	2860	3220	3600	4015	4485	5015	5680	246	214	214
400	366	328	20	1276	1449	1633	1840	2055	2300	2575	2900	3265	3680	4110	4585	5130	5735	6490	282	245	245
450	406	366	19	1436	1630	1837	2070	2310	2585	2900	3260	3675	4140	4625	5160	5770	6450	7300	312	274	274
500	445	404	18	1595	1812	2042	2300	2570	2870	3220	3625	4085	4600	5140	5735	6410	7165	8115	341	302	302

/// TYPICAL 1 ϕ MOTOR, CAPACITOR-START

|| TYPICAL 3 ϕ PROTECTED MOTOR 1800 RPM AND 3600 RPM

|| TYPICAL 3 ϕ TOTALLY ENCLOSED 3600 AND 1800 RPM MOTORS OR MOTORS WOUND WITH ALUMINUM WIRE

STANDARD VOLTAGES FOR GENERATORS DIFFER FROM THE CORRESPONDING STANDARD VOLTAGES FOR MOTORS. THE TWO NEMA STANDARDS MG1-10.30 AND MG1-22.13 LIST MOTOR AND GENERATOR VOLTAGES AS SHOWN IN TABLE 2A. FOR THESE CORRESPONDING "STANDARD" VOLTAGES USE THE STARTING KVA AS SPECIFIED IN TABLE 2. IF CORRESPONDING VOLTAGES ARE "NON-STANDARD," MODIFY THE STARTING KVA BY THE MULTIPLICATION FACTOR GIVEN IN TABLE 2B.

*PREVIOUS STANDARD VOLTAGE WAS 220 VOLTS SHOULD 9E OPERATED ON 240 VOLTS WHENEVER POSSIBLE.

TABLE 2A.

STANDARD VOLTAGES	
GENERATOR NAMEPLATE VOLTAGE	MOTOR NAMEPLATE VOLTAGE STAMPING
120	115
120 200 OR 208	200
240	230*
480	575
600	

TABLE 2B.

FOR VOLTAGES OTHER THAN STANDARD		
FOR VOLTAGES OTHER THAN NORMAL		
GEN. VOLTS NAMEPLATE	MOTOR VOLTS NAMEPLATE	MULTIPLY TABLE 2 STARTING KVA BY
MOTOR VOLTAGE SAME AS GEN VOLT		
208	220	0.9246
416	440	0.8939
240	220	1.1187
480	440	

**TABLE 3. MOTOR STARTING CAPABILITIES OF
ONAN BRUSHLESS, REVOLVING FIELD GENERATOR SETS
DIESEL ENGINES, 3Ø, 60HZ**

GENERATOR SERIES

MODEL	MAXIMUM KVA COL. 10				MAXIMUM KW* COL. 11		RATED KVA COL. 12	RATED KW* COL. 13	MAX. KVA WHEN PURCHASED WITH A FULL POWER 1Ø OPTION. COL. 10			
	3Ø 120/208 240/416 120/2400 (YD)	3Ø 127/220 254/440	3Ø 139/240 277/480 347/800 120/2400UR & YB FOR 1Ø	1Ø 120/240 (3Ø GEN CONNECTED FOR 1Ø)	STD (SEE T-017)	CITY WATER COOLED			3Ø 120/208 240/416 120/2400 (YD)	3Ø 127/220 254/440 120/2400 (UR)	3Ø 139/240 277/480 347/800	1Ø 120/240 (3Ø GEN CONNECTED FOR 1Ø)
AIR COOLED												
6 0 DJB	26	27	28	18	6.7		7.5	6.0	32	33	34	22
12 0 DJC	43	44	45	32	13.4		15.6	12.5	48	50	52	37
LIQUID COOLED												
7.5 MDJE	32	33	34	22			9.4	7.5	38	38	40	27
12 0 MDJC	43	44	45	32			15.6	12.5	48	50	52	37
15 0 RDJC	48	50	52	37	15.7		18.7	15.0	54	55	56	42
15 0 RDJC	48	50	52	37			18.7	15.0	54	55	56	42
17 5 RDJF	54	55	56	42	17.5		21.8	17.5				
3Ø DER(WDEH)	90	102	115	75	33		37.5	30	162	178	189	125
3Ø DBA	162	178	189	125	35		56	45	230	240	251	165
45 DEF					45							
45 DYJ					55		62.5	50	263	277	286	190
50 OEG(WDEG)	162	178	189	125	55							
50 ODB	230	240	251	165	66	67	75	60	336	347	357	235
60 DYA	283	277	286	190	106	109	94	75	380	391	400	266
75 DYC					106	109	112.5	90	432	440	450	300
90 DYC	297	309	318	210	106	109	125	100	481	490	498	330
100 DYC	336	347	357	235	106	109	156	125	520	526	530	350
125 DYD	432	440	450	300	141	144	187	150				
150 DYD	485	495	505	330	207	215	193	155				
155 DFE	485	495	505	330	240	246						
175 DYD	550	560	570	350	207	215	218	175				
180 DFE	550	560	570	350	240	246	225	180				
200 DFP	578	620	631	420	240	246	250	200				
200 DYC					202	212	287	230				
230 DFP	730	758	800	530	240	246	312	250				
250 DYH	815	840	884	576	257	267						
250 DFM					267	275						
300 DFS	900	928	950	633	310	321	375	300				
350 DFN												
350 DFB	912	942	972	650	376	388	437	350				
400 0 DFX					461	475	560	400				
450 0 DFX	988	-	1040		461	475	560	400				
500 0 DFX	1085	-	1200		521	534	625	500				
600 0 DFX	1176	-	1370		625	-	750	600				
750 0 DFX	1677	-	1780		785	807	937	750				
1960		-	2080									

*USE FOR MOTOR STARTING CALCULATION ONLY. THESE VALUES
USUALLY MUST BE DERATED ABOVE 1000 FEET AND 80°F. SEE T-017

**TABLE 4. MOTOR STARTING CAPABILITIES OF ONAN
BRUSHLESS, REVOLVING FIELD GENERATOR SETS
DIESEL ENGINES, 1Ø AND 3Ø, 50HZ**

GENERATOR SERIES	MODEL	MAXIMUM KVA COL. 10						OVERLOAD ²		CONTINUOUS ¹	
		3Ø		3Ø		1Ø		RATED KVA COL. 11	RATED KW COL. 12	RATED KVA COL. 13	RATED KW COL. 14
		110/190 Y 220/380 Δ	110/220 Y 230/400 Δ	115/230 Y 110/220 Δ	120/240 Y 120/240 Δ	110/220 Y 110/220 Δ	115/230 Y 115/230 Δ				
AIR COOLED	4.50JB-53CR	-	-	-	-	11	12	4.5	4.5	4.5	4.5
	4.50JB-51BR	22	23	25	25	14	15	4.5	5.6	4.5	4.5
	9.00JC-53CR	-	-	-	-	25	26	9.0	9.0	9.0	9.0
	9.00JC-51BR	36	39	39	39	24	25	11.2	11.2	9.0	9.0
LIQUID COOLED	6.0MDJE-53CR	-	-	-	-	14	15	6.0	6.0	6.0	6.0
	6.0MDJE-51BR	27	28	30	30	18	19	7.5	7.5	6.0	6.0
	10.0MDJC-53CR	-	-	-	-	25	26	10.0	10.0	10.0	10.0
	10.0MDJC-51BR	36	37	39	39	24	25	12.5	12.5	10.0	10.0
	12.5RDJC-53CR	-	-	-	-	30	31	12.5	12.5	12.5	12.5
SR	12.5RDJC-51BR	40	41	42	43	27	28	15.6	15.6	12.5	12.5
	12.0MDJF-53CR	-	-	-	-	30	31	12.0	12.0	12.0	12.0
	12.0MDJF-51BR	40	41	42	43	27	28	12.0	12.0	12.0	12.0
	14.5RDJE-53CR	-	-	-	-	33	34	14.5	14.5	14.5	14.5
	14.5RDJE-51BR	45	46	47	48	33	34	18.1	18.1	14.5	14.5
UV	25.0DEH(MDEH)	55	62	70	80	46	53	36.5	29.0	32.5	26.0
	25.0DDA	55	62	70	80	46	53	36.5	29.0	32.5	26.0
	37.5DEF	102	112	123	131	82	87	51.0	41.0	46.0	37.0
	37.5DYJ	102	112	123	131	82	87	51.0	41.0	46.0	37.0
	40.0DEG(MDEG)	102	112	123	131	82	87	55.0	44.0	50.0	40.0
YB	40.0DDB	102	112	123	131	82	87	54.0	43.0	49.0	39.0
	50.0DYA	153	160	167	173	111	115	66.0	53.0	60.0	48.0
	62.5DYC	174	183	192	200	126	132	86.0	69.0	79.0	63.0
	75.0DYC	200	206	214	220	140	146	100.0	80.0	91.0	73.0
	80.0DYD	226	233	240	248	160	165	118.0	94.0	106.0	85.0
YB	100.0DYO	295	300	305	312	203	208	138.0	110.0	125.0	100.0
	125.0DYG	328	336	344	351	229	234	173.0	138.0	158.0	126.0
	130.0DDE	328	336	344	351	229	234	179.0	143.0	163.0	130.0
	145.0DYG	375	382	389	396	259	264	173.0	138.0	158.0	126.0
	150.0DDE	375	382	389	396	259	264	206.0	163.0	188.0	150.0
YB	153.0DYG	374	401	430	436	211	216	169	138.0	191	153
	165.0DFP	374	401	430	436	211	216	182.0	146.0	206.0	165.0
	190.0DFP	487	506	526	555	245.0	255.0	196.0	158.0	223.0	178.0
	210.0DFM	550	566	583	600	275.0	285.0	220.0	178.0	250.0	200.0
	210.0DYB	550	566	583	600	248.0	258.0	198.0	158.0	225.0	180.0
YB	250.0DFS	606	625	644	660	338.0	348.0	270.0	218.0	306.0	245.0
	290.0DFN	612	633	654	675	398.0	408.0	318.0	258.0	360.0	288.0
	290.0DHB	612	633	654	675	336.0	346.0	269.0	219.0	305.0	244.0
	330.0DFV	722	760	785	810	458.0	468.0	366.0	296.0	416.0	333.0
	400.0DFW	833	876	905	934	503.0	513.0	402.0	332.0	456.0	365.0
UV	500.0DFX	1236	1300	1340	1380	650.0	660.0	520.0	430.0	591.0	473.0
	625.0DFZ	1444	1520	1570	1610	810.0	820.0	648.0	538.0	736.0	589.0

1) a. THE POWER LISTED FOR SETS UTILIZING THE UR, YB, UV SERIES GENERATORS IS THE POWER AVAILABLE FOR CONTINUOUS USE AT BRITISH STANDARD (B.S.) 649:1958 AND DEUTSCHES INSTITUT FÜR NORMUNG (DIN) "CONTINUOUS OUTPUT A" 6270 STANDARD CONDITIONS. ALTHOUGH THESE STANDARD CONDITIONS ARE NUMERICALLY DIFFERENT, THEIR OVERALL EFFECT IS VIRTUALLY EQUIVALENT.

b. GENERATORS ARE APPLIED AT MAXIMUM CONTINUOUS RATING (MCR) OF B.S. 2613:1970 AND INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC) PUBLICATION 34-1. IEC PUBLICATION 34-1 IS EQUIVALENT TO VERBAND DEUTSCHER ELEKTROTECHNIKER (VDE) 0530 TEIL 1/11.72.

2) a. THE POWER LISTED FOR SETS UTILIZING THE UR, YB, UV SERIES GENERATORS IS THE POWER AVAILABLE FOR 1 HOUR IN 12 HOURS AT B.S. 649:1958 AND DIN 6270 STANDARD CONDITIONS. THIS RATING IS AT LEAST 110% OF THE CONTINUOUS RATING.

**TABLE 5. MOTOR STARTING CAPABILITIES OF ONAN
BRUSHLESS, REVOLVING FIELD GENERATOR SETS
GASOLINE OR GASEOUS FUELED ENGINES, 3Ø, 60HZ**

MODEL	MAXIMUM KVA COL. 10				MAXIMUM KW* COL. 11			CITY WATER COOLING ADD THIS KW	RATED KVA COL. 12	RATED KW* COL. 13	MAX KVA (WHEN PURCHASED WITH FULL POWER 1Ø OPT) COL. 10			
	3Ø 120/208 240/416 [120/2400] (YD)	3Ø 127/220 254/440 [120/2400] (UR)(YB)	3Ø 139/240 277/480 347/600	1Ø 120/240 WHEN 3Ø GEN CONNECTED FOR 1Ø	GASOLINE — SEE T-017 —	PROPANE	NAT. GAS				3Ø 120/208 240/416 [120/2400] (YD)	3Ø 127/220 254/440 [120/2400] (UR)(YB)	3Ø 139/240 277/480 347/600	1Ø 120/240 WHEN 3Ø GEN CONNECTED FOR 1Ø
AIR COOLED														
7.5JB	32	33	34	22	8.0	7.8	7.5	-	9.4	7.5	38	39	40	27
12.5JC	43	44	45	32	17.0	16.0	13.5	-	15.6	12.5	48	50	52	37
15.0JC	48	50	52	37	17.0	16.0	13.5**	-	18.7	15.0	54	55	56	42
LIQUID COOLED														
10.0MJC	38	39	40	27	17	NA	NA	-	12.5	10.0	43	44	45	32
12.5RJC	43	44	45	32	17	16.5	16	-	15.6	12.5	48	50	52	37
15.0MJC	48	50	52	37	17	NA	NA	-	18.7	15.0	54	55	56	42
15.0RJC	48	50	52	37	17	16.5	16	-	18.7	15.0	54	55	56	42
30 SK	100	112	125	75	37.0	33.5	26.8	-	37.5	30.0	150	168	187	110
30 EK	90	102	115	75	33	31	28	-	37.5	30.0	162	178	189	125
45 EM	162	178	190	125	48	45	39	-	56.0	45.0	230	240	251	165
55 EN	195	210	220	146	78	65	55	3.0	68.0	55.0	297	309	318	212
55 KB	195	210	220	146	65	58	52	3.0	68.0	55.0	297	309	318	212
65 KB	230	240	250	165	65	NA	NA	3.0	81.0	65.0	336	347	357	235
70 EN	263	277	286	190	78	NA	NA	-	87.0	70.0	380	391	400	266
85 KR	297	309	318	210	93	85	77**	-	106.0	85.0	432	440	450	300
115 WA	380	391	400	266	120	119	118	3.0	143.0	115.0	520	526	530	350
170 WB	520	526	530	350	185	180	174**	10	212.0	170.0				
250 FT	815	840	846	576	NA	NA	280	10	312.0	250.0				
350 WF	912	942	972	650	NA	NA	390	20	437.0	350.0				
400 WK	980	-	1040		NA	NA	480	20	500.0	400				

* USE FOR MOTOR STARTING CALCULATIONS ONLY. SEE T-017 FOR ALTITUDES ABOVE 1000 FEET AND FUEL DERATINGS

** HIGH COMPRESSION HEAD WILL INCREASE THIS VALUE SEE T-017.

TABLE 6. MOTOR STARTING CAPABILITIES OF ONAN BRUSH-TYPE, REVOLVING ARMATURE GENERATOR SETS (1Ø & 3Ø, 50 & 60HZ)

6A. SPARK IGNITION ENGINES (60 Hz)

MODEL	PHASE	MAXIMUM KW				RATED KVA	RATED KW
		MAX KVA COL. 10	GASOL COL. 11	PROPANE - SEE T-017 - COL. 11	NAT'L GAS COL. 11		
AIR COOLED 1.0AJ 1.5AK 2.5AJ 2.5AJ* 2.7AJ	1	2.3	1.1	-	-	1.0	1.0
	1	2.6	1.6	-	-	1.5	1.5
	1	4.4	2.5	-	-	2.5	2.5
	1	6.0	2.5	2.4	2.3	2.5	2.5
	1	5.8	2.7	-	-	2.7	2.7
2.5LK 4.0CCK 4.0CCK 5.0CCK 5.0CCK	1	5.8	2.6	2.5	2.1	2.5	2.5
	1	8.0	4.8	4.7	4.3	4.0	4.0
	3	9.6	4.8	4.7	4.3	4.0	4.0
	1	12.5	5.2	5.0	4.6	5.0	5.0
	3	14.0	5.2	5.0	4.6	5.0	5.0
6.5NH 6.5NH	1	14.0	6.8	5.8	4.8	6.5	6.5
	3	16.0	6.8	5.8	4.8	6.5	6.5
10.0CCRB 10.0CCRB	1	16.0	10.2	9.5	8.0	10.0	10.0
	3	16.0	10.2	9.5	8.0	10.0	10.0
LIQUID COOLED 3.0MAJ 4.0MCCK	1	6.0	3.0	NOT AVAILABLE		3.0	3.0
	1	9.6	5.0			4.0	4.0
6.5MCCK	1	12.5	6.5			6.5	6.5
	1						
AIR COOLED 1.2TW 1.7TN 2.0TP 3.0TR 4.5TS 5.5TT	1			SEE TABLE 7		1.2	1.2
	1					1.7	1.7
	1					2.0	2.0
	1					3.0	3.0
	1					4.5	4.5
	1					5.5	5.5

* Electric Start Model.

6C. DIESEL ENGINES

MODEL	HZ	PHASE	MAXIMUM				RATED KW COL. 13
			MAX KVA COL. 10	MAX KW COL. 11	RATED KVA COL. 12	RATED KW COL. 13	
AIR COOLED 2.5DJA 3.0DJA	50	1	5.0	2.5	2.5	2.5	
	60	1	6.0	3.0	3.0	3.0	
LIQUID COOLED 2.5MDJA 3.0MDJA	50	1	5.0	2.7	2.5	2.5	
	60	1	6.0	3.2	3.0	3.0	

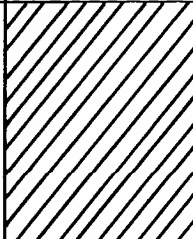
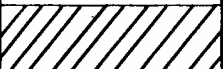
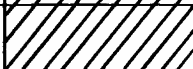
6B. SPARK IGNITION ENGINES (50 Hz)

MODEL	PHASE	MAX KVA		MAX KW		RATED KVA		RATED KW	
		COL. 10	COL. 11	COL. 10	COL. 11	COL. 12	COL. 13	COL. 12	COL. 13
AIR COOLED 1.2AR 2.0AJ 2.0AJ* 2.7K 3.5CCK	1	2.1	1.2	2.1	1.2	1.2	1.2	1.2	1.2
	1	3.7	2.0	3.7	2.0	2.0	2.0	2.0	2.0
	1	5.0	2.0	5.0	2.0	2.0	2.0	2.0	2.0
	1	4.0	1.7	4.0	1.7	1.7	1.7	1.7	1.7
	1	6.0	3.5	6.0	3.5	3.5	3.5	3.5	3.5
4.2CCK 4.2CCK 5.5NH 5.5NH	1	8.0	4.2	8.0	4.2	4.2	4.2	4.2	4.2
	3	9.0	4.2	9.0	4.2	4.2	4.2	4.2	4.2
	1	11.0	5.5	11.0	5.5	5.5	5.5	5.5	5.5
	3	13.0	5.5	13.0	5.5	5.5	5.5	5.5	5.5
	3								
LIQUID COOLED 3.5MCCK 5.5MCCK		6.0	3.5	6.0	3.5	3.5	3.5	3.5	3.5
		9.0	5.5	9.0	5.5	5.5	5.5	5.5	5.5
AIR COOLED 1.0TW 1.4TN 1.6TP 2.5TR 3.7TS 4.5TT	1	1.6	1.0	1.6	1.0	1.0	1.2	1.2	1.2
	1	2.8	1.4	2.8	1.4	1.4	1.4	1.4	1.4
	1	2.9	1.8	2.9	1.8	1.8	1.6	1.6	1.6
	1	4.6	2.5	4.6	2.5	2.5	2.5	2.5	2.5
	1	6.8	3.7	6.8	3.7	3.7	3.7	3.7	3.7
	1	10.0	4.5	10.0	4.5	4.5	4.5	4.5	4.5

CAUTION

On revolving armature generator sets, maximum kVA in column 10 is not a true value but an equivalent we use to permit standardization on unit selection procedures. It is what the generator set would appear to produce if it could maintain rated voltage under motor starting conditions. Actually, the voltage will dip to about 70 percent of rated value resulting in about 50 percent reduction of kVA during motor starting. Similar to reduced voltage starters, this permits starting relatively larger motors. Remember, the starting torque of the motor is proportional to the kVA input and reducing it by 50 percent will cut the stalled torque in half. This may cause some problems if the motor must start while it is heavily loaded (compressors, piston pumps, conveyors, etc.). For such cases, it may be necessary to select the next size larger generator set.

**TABLE 7. DETERMINING SET SIZE WHEN LOADS ARE SMALL
SINGLE-PHASE MOTORS***

MOTOR HP RATING	APPROXIMATE RUNNING WATTS	MINIMUM WATTAGE RATING OF GENERATOR SET REQUIRED**			
		UNIVERSAL MOTOR	REPULSION INDUCTION MOTOR	CAPACITOR MOTOR	SPLIT PHASE MOTOR
1/6	275	400	600	600	1000
1/4	400	500	850	800	1500
1/3	500	600	950	1200	2000
1/2	700	750	1300	1500	2500
3/4	950	1000	1900	2100	
1	1200	1200	2300	2500	
1-1/2	1600	1750	3200	3200	
2	2200	2300	3900	3500	
3	3200		5200	4200	

* Use next size larger generator set for hard-starting loads such as compressors, residential air conditioners, freezers, etc.

** For applications with only one motor load, this would equal minimum generator set size.

NOTE: Do not use this table for mobile type air conditioners. Contact the factory or distributor.

Calculation

Lighting Load	+	Approx. Watts of Motors Running	+	Minimum Starting Watts of Last Motor Started	=	Minimum Size Continuous Rating of Generator Set
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Sample

1000 Watts (Lights)	+	700 Running Watts (½ HP Fan Motor)	+	2100 Starting Watts (¾ HP Capacitor Start Motor)	=	3800 Watts Total Load	➞	Recommended Minimum Size Generator Set 4000 Watts
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TABLE 8. ONAN PTO ALTERNATOR (60 Hz, 1Ø AND 3Ø) MOTOR STARTING CAPABILITIES

MODEL	MAXIMUM kVA Col. 10	MAXIMUM* kW Col. 11	RUN kVA Col. 12	RUN* kW Col. 13	Minimum HP Input for Proper Performance	PTO RPM	PHASE	VOLTAGE	POWER FACTOR	AMPERE at 240 V
15.0 UF-3S/	22.5§	15.0	15.0	15.0	30	540	1	120/240	1.0	62.5
15.0 YD-3G/	37.5	15.0	15.0	15.0	30	540	1	120/240	1.0	62.5
20.0 YD-3G	52.0	20.0	20.0	20.0	37	540	1	120/240	1.0	83.3
20.0 YD-5DG	57.5	20.0	25.0	20.0	37	540	3	120/240D	0.8	60.0
25.0 UT-3S/	37.5	25.0	25.0	25.0	45	540	1	120/240	1.0	104.0
25.0 UT-5DS/	37.5	25.0	31.2	25.0	45	540	3	120/240D	0.8	75.0
25.0 YD-3G/	62.5	25.0	25.0	25.0	45	540	1	120/240	1.0	104.0
25.0 YD-5DG/	70.0	25.0	31.2	25.0	45	540	3	120/240D	0.8	75.0
30.0 YD-3G	80.0	30.0	30.0	30.0	55	540	1	120/240	1.0	125.0
30.0 YD-5DG	95.0	30.0	37.5	30.0	55	540	3	120/240D	0.8	90.0
45.0 UR-3G/	120.0	45.0	45.0	45.0	82	1000	1	120/240	1.0	187.5
45.0 UR-5DG/	165.0	45.0	56.2	45.0	82	1000	3	120/240D	0.8	135.5
65.0 UR-3G/	163.0	65.0	65.0	65.0	120	1000	1	120/240	1.0	271.0
65.0 UR-5DG/	208.0	65.0	81.2	65.0	120	1000	3	120/240D	0.8	195.5
80.0 UR-5DG	300.0	80.0	100.0	80.0	145	1000	3	120/240D	0.8	241.0

* This value will be lower (or higher) if tractor HP is less (or more) than value in minimum HP column.

§ With boost field, value is 25.4 kVA.

PART II

THEORY AND PROBLEMS ASSOCIATED WITH COMMON LOAD APPLICATIONS

CODE LETTER AND DESIGN LETTER

All standard motors which meet NEMA (National Electrical Manufacturers Association) MG1-10.36 specifications have the locked rotor kVA printed on the nameplate in the form of a code letter. For example, a 15 HP motor with 105 locked rotor amperes at 460 volts and 210 locked rotor amperes at 230 volts would have a code letter "F" in both cases.

The NEMA letter designations for locked rotor kVA/HP as measured at full voltage and rated frequency are as shown below.

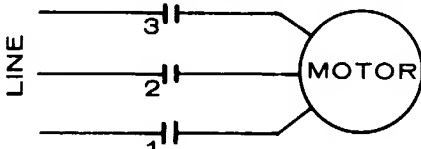
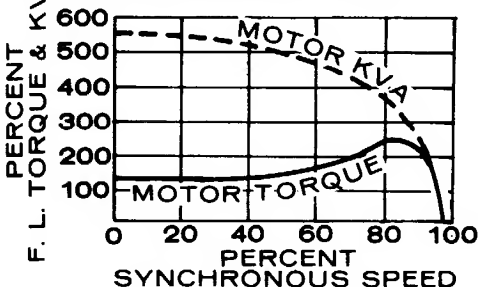
CAUTION Do not confuse the code letter with the design letter. A design letter is the NEMA designation denoting the torque versus speed characteristics (Figure 1). The design letter is not associated with the locked rotor kVA.

Letter Designation	kVA per Horsepower	*Average kVA/HP
A	0- 3.15	2.95
B	3.15- 3.55	3.35
C	3.55- 4.0	3.77
D	4.0 - 4.5	4.25
E	4.5 - 5.0	4.75
F	5.0 - 5.6	5.30
G	5.6 - 6.3	5.95
H	6.3 - 7.1	6.70
J	7.1 - 8.0	7.55
K	8.0 - 9.0	8.50
L	9.0 -10.0	9.50
M	10.0 -11.2	10.60
N	11.2 -12.5	11.85
P	12.5 -14.0	13.25
R	14.0 -16.0	15.00
S	16.0 -18.0	17.00
T	18.0 -20.0	19.00
U	20.0 -22.4	21.20
V	22.4 and up	

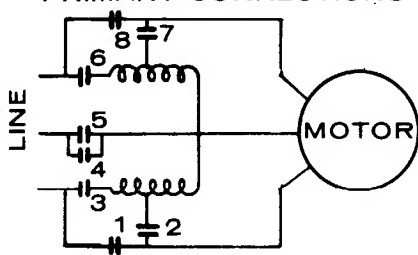
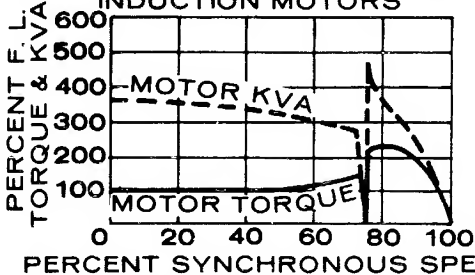
* Average of NEMA values is used by Onan as basis for values used in Table 2. The above chart, however, is based upon generator voltage being equal to motor voltage. Therefore, a 0.9246 factor is utilized (per Table 2B) to arrive at values for Table 2.

TYPICAL MOTOR STARTING SYSTEMS*

FULL VOLTAGE MOTOR STARTING

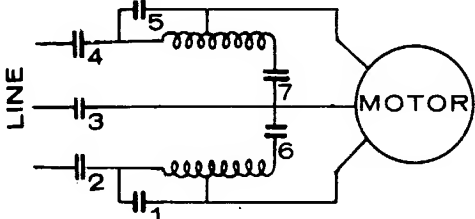
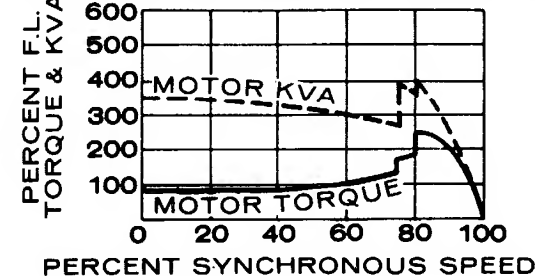
STARTING	APPLICATION NOTES	<p>STARTING DIAGRAM PRIMARY CONNECTIONS</p>  <p>START: CLOSE 1-2-3 RUN: NO CHANGE</p> <p>TYPICAL KVA AND TORQUE CURVES FOR SQUIRREL-CAGE INDUCTION MOTORS</p> 
<p>Full voltage starting should always be used unless limited capacity of the generator set makes reduced kVA starting necessary or reduced voltage dip is required during motor starting. There is no limit to the HP, size, voltage rating or type of motor.</p>	<p>Across-the-line, full voltage starting most commonly used due to simplicity, reliability, and initial low cost. Note on kVA and torque curves that starting kVA remains fairly constant until motor almost reaches full speed.</p>	

AUTOTRANSFORMER MOTOR STARTING, OPEN TRANSITION

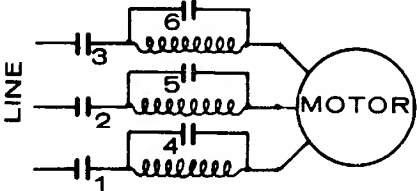
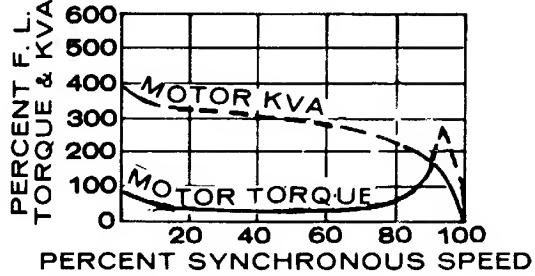
STARTING	APPLICATION NOTES	<p>STARTING DIAGRAM PRIMARY CONNECTIONS</p>  <p>START: CLOSE 2-3-5-6-7 RUN: OPEN 2-3-5-6-7 CLOSE 1-4-8</p> <p>TYPICAL KVA AND TORQUE CURVES FOR SQUIRREL-CAGE INDUCTION MOTORS</p> 
<p>Only in the circuit during starting, the autotransformer reduces voltage to the motor. Opening of the circuit during transition permits the possibility of relatively severe transients and could cause nuisance tripping of circuit breakers.</p>	<p>Open transition types of reduced voltage starters should be avoided for generator set applications particularly when the motor is not up to full speed at time of transition. When the switch opens for transition, the motor slows down so that when the switch closes on the run winding, the motor is not synchronized. The resulting transients are similar to paralleling generators out of phase. The kVA drawn immediately after switching to the line could exceed starting kVA. Autotransformers lower power factor during starting.</p>	

* Typical curves are shown for descriptions of motor starting methods only. Do not use curves for calculations.

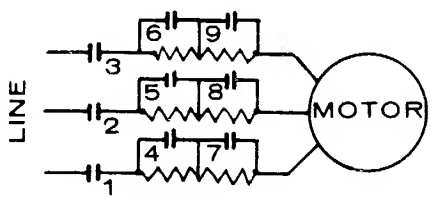
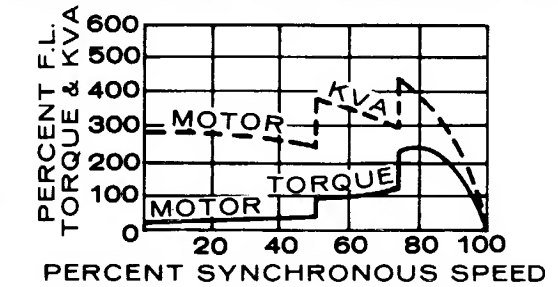
AUTOTRANSFORMER MOTOR STARTING, CLOSED TRANSITION

STARTING	APPLICATION NOTES	<p style="text-align: center;">STARTING DIAGRAM PRIMARY CONNECTIONS</p>  <p style="text-align: center;">START: CLOSE 6-7 AND 2-3-4 TRANSFER: OPEN 6-7 RUN: CLOSE 1-5</p> <p style="text-align: center;">TYPICAL KVA AND TORQUE CURVES FOR SQUIRREL-CAGE INDUCTION MOTORS USING 80% TAP</p> 
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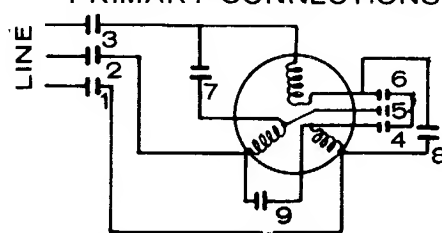
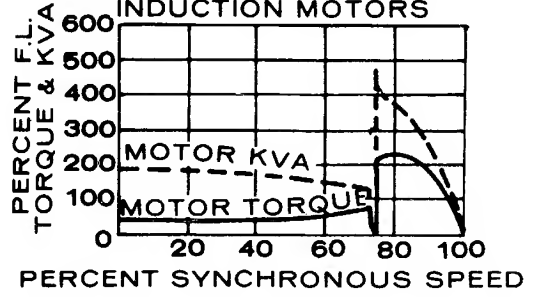
REACTOR MOTOR STARTING, CLOSED TRANSITION

STARTING	APPLICATION NOTES	<p style="text-align: center;">STARTING DIAGRAM PRIMARY CONNECTIONS</p>  <p style="text-align: center;">START: CLOSE 1-2-3 RUN: CLOSE 4-5-6</p> <p style="text-align: center;">TYPICAL KVA AND TORQUE CURVES FOR SQUIRREL-CAGE INDUCTION MOTORS</p> 
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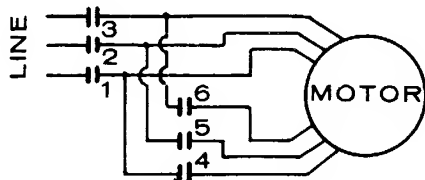
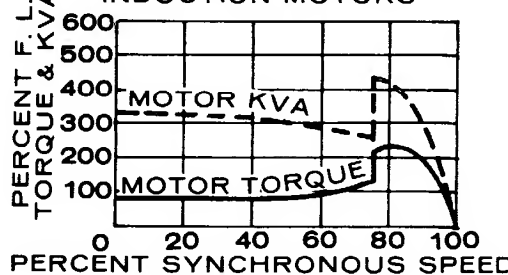
RESISTOR MOTOR STARTING, CLOSED TRANSITION

STARTING	APPLICATION NOTES	STARTING DIAGRAM PRIMARY CONNECTIONS								
<p>Resistor starting is occasionally used for smaller motors where several steps of starting are required and no opening of motor circuit between steps is allowed.</p>	<p>Also available as a stepless transition starter which provides a smoother start. Resistor starting is usually the least expensive with small motors. Has a higher starting power factor. When actual power factor isn't known, use table. Accelerates loads faster because the voltage increases with a decrease in current.</p> <table><tr><th>TAP</th><th>USE P.F.</th></tr><tr><td>80%</td><td>0.6</td></tr><tr><td>65%</td><td>0.7</td></tr><tr><td>50%</td><td>0.8</td></tr></table>	TAP	USE P.F.	80%	0.6	65%	0.7	50%	0.8	 <p>START: CLOSE 1-2-3 SECOND STEP: CLOSE 4-5-6 THIRD STEP: CLOSE 7-8-9</p> <p>TYPICAL KVA AND TORQUE CURVES FOR SQUIRREL-CAGE INDUCTION MOTORS USING 50% TAP</p> 
TAP	USE P.F.									
80%	0.6									
65%	0.7									
50%	0.8									

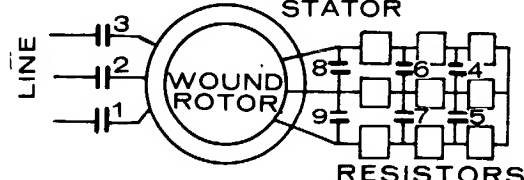
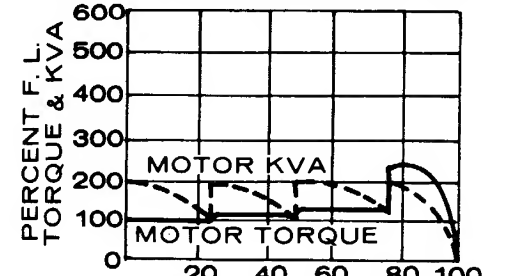
STAR-DELTA MOTOR STARTING, OPEN TRANSITION

STARTING	APPLICATION NOTES	STARTING DIAGRAM PRIMARY CONNECTIONS
<p>Star-delta starting requires no autotransformer, reactor or resistor. The motor starts as a star-connected motor and runs delta connected.</p>	<p>This starting method is becoming more popular where low starting torques are accepted. Has the following disadvantages:</p> <ol style="list-style-type: none"> 1. Open transition; closed transition available at extra cost. 2. Low torque. 3. No advantage when motor is powered by generator set unless motor reaches synchronous speed before switching to run winding. <p>In applications where motor does not reach synchronous speed before switching to run winding, generator set must be sized to meet surge.</p>	 <p>START: CLOSE 1-2-3-4-5-6 RUN: OPEN 4-5-6 CLOSE 7-8-9</p> <p>TYPICAL KVA AND TORQUE CURVES FOR SQUIRREL-CAGE INDUCTION MOTORS</p> 

PART WINDING MOTOR STARTING, CLOSED TRANSITION

STARTING	APPLICATION NOTES	<p style="text-align: center;">STARTING DIAGRAM PRIMARY CONNECTIONS</p>  <p style="text-align: center;">START: CLOSE 1-2-3 RUN: CLOSE 4-5-6</p> <p style="text-align: center;">TYPICAL KVA AND TORQUE CURVES FOR SQUIRREL-CAGE INDUCTION MOTORS</p> 
<p>Part winding starting is less expensive because it requires no autotransformer, reactor or resistor and uses simple switching. Available in two or more starting steps depending on size, speed and voltage of motor.</p>	<p>Automatically provides closed transition. First, one winding is connected to the line; after a time interval, the second winding is paralleled with the first. Starting torque is low and is fixed by the motor manufacturer. The purpose of part winding is not to reduce starting current but to provide starting current in smaller increments.</p> <p><i>No advantage when motor is powered by a generator set unless the motor can reach synchronous speed before transition to the line.</i></p>	

WOUND ROTOR MOTOR STARTING

STARTING	APPLICATION NOTES	<p style="text-align: center;">STARTING DIAGRAM PRIMARY CONNECTIONS</p>  <p style="text-align: center;">START: CLOSE 1-2-3 FIRST STEP: CLOSE 4-5 SECOND STEP: CLOSE 6-7 RUN: CLOSE 8-9</p> <p style="text-align: center;">TYPICAL KVA AND TORQUE CURVES FOR WOUND ROTOR MOTORS</p> 
<p>A wound rotor motor can have the same starting torque as a squirrel cage motor but with less current. Differs from squirrel cage motors only in the rotor. Squirrel cage motor has short circuit bars, wound rotor motor has windings, usually three phase.</p>	<p>Starting current, torque and speed characteristics can be changed by connecting the proper amount of external resistance into the rotor. Usually the wound rotor motors are adjusted so that the starting kVA is about 1.5 times the running kVA. This is the easiest type of motor for a generator set to start. If wound rotor motors are used for variable speed applications, contact your distributor for information.</p>	

SYNCHRONOUS MOTORS

STARTING	APPLICATION NOTES
<p>Synchronous motors can use most of the starting methods as previously listed. Synchronous motors 20 HP and larger have starting characteristics similar to the wound rotor motors.</p>	<p>Synchronous motors are in a class by themselves. There are no standards of performance, frame sizes, or connections for these motors. Synchronous motors 30 horsepower and smaller have high lock rotor current. Use in applications where power factor correction is desired. (Use the standard code letter when the actual letter is unknown.)</p>

REDUCED VOLTAGE MOTOR STARTING

Although voltage dip often causes various problems, a controlled reduction in voltage can be beneficial when used to reduce the starting kVA of a motor. Whenever the starting kVA is reduced, the size of the generator set required is smaller, voltage dip is less and the motor load has a softer start. Reduced voltage starters can be used whenever the reduction of the motor's torque will not hinder the application.

CAUTION Before adding reduced voltage motor starters to equipment, consult the manufacturer of the equipment. The torque of the motor may be reduced to the point the motor can't start or accelerate the load. Motor damage could result.

Table 9 compares different types of reduced voltage motor starting methods with their associated reduction in kVA and torque. Variations of these types of

reduced voltage motor starters may be available from local suppliers.

Application Note: If the reduced voltage motor starter has a time or rate adjustment, adjust the settings to about two seconds between taps. This allows shaft speed to approach synchronous speed and reduce the peak kVA at the time of switching. A reduced voltage starter set in minimum position is not much of an improvement over full voltage starting as shown in Figure 2.

In some applications, the inrush current is so low, the motor shaft will not turn on the first and often the second tap. For this type of application, there is little reduction of starting kVA from the standpoint of the generator set.

TABLE 9. REDUCED VOLTAGE STARTING METHODS WITH CHARACTERISTICS

STARTING METHOD	% VOLTS APPLIED (TAP)	% F.V. kVA	% F.V. TORQUE	MULTIPLYING FACTOR
Full Voltage	100	100	100	1.0
Reduced Voltage Autotransformer	80	64	64	0.64
	65	42	42	0.42
	50	25	25	0.25
Series Reactor or Resistor	80	80	64	0.80
	65	65	42	0.65
	50	50	25	0.50
Star Delta	100	33	33	0.33
Part Winding (Typical)	100	60	48	0.6
Wound Rotor Motor	100	160*	100*	1.6 *

* Of running current. Depends on value of series resistance added to the rotor. (See section on Wound Rotor Motors, p. 19.)

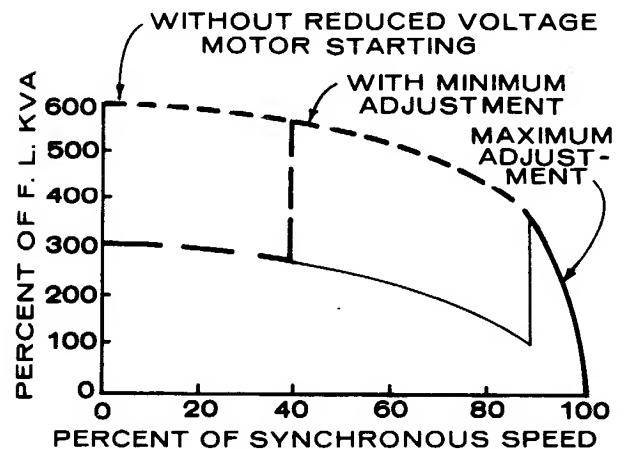


FIGURE 2. REDUCED VOLTAGE MOTOR STARTING EFFECTS

A SAMPLE MOTOR STARTING PROBLEM IS LOCATED ON NEXT PAGE.

Following is a sample motor starting problem using reduced voltage starting. The motor is 50 horsepower, 460 volts, code F, has a starting kVA of 287 and a 0.36 starting PF. The generator set output is 480 volts. See Table 10.

TABLE 10. SAMPLE MOTOR STARTING PROBLEM

	TYPE OF STARTER		
	AUTOTRANSFORMER	RESISTOR	FULL VOLTAGE
% of applied volts (tap)	65	50	100
% of full voltage (multiplier)	0.42	0.50	1.0
Starting kVA with reduced voltage motor starter	$287 \times 0.42 = 120.5$	$287 \times 0.50 = 143.5$	$287 \times 1.0 = 287$
Starting kW with starter (kVA x PF)	$120.5 \times 0.36 = 43.4$	$143.5 \times 0.8 \text{ PF}^* = 114.8$	$287 \times 0.36 \text{ PF} = 103.3$
Run kVA	49.4	49.4	49.4
Run kW	41	41	41
†Generator set (gasoline)	45.0EM	115.0WA	115.0WA
†Generator set (diesel)	45.0DEF	100.0DYD	100.0DYD

* - See description of resistor motor starting, closed transition.

† - From Tables 4 and 6 of Part I.

Conclusion: Autotransformer starting and wound rotor motor starting require the least motor starting capacity from the generator set, and allow the smallest capacity generator set to be purchased. Resistor starting and part winding motors have little effect on reducing the capacity requirement of the generator set.

X-RAY APPLICATIONS

X-ray applications are somewhat difficult due to the limited information available from the X-ray equipment manufacturers. The essential information needed to properly size a generator set is the peak kVA load (kVP x ma) and the allowable voltage dip.

For all X-ray applications, two important factors must be understood:

1. The operator must realize when the X-ray equipment is powered by the generator set, the picture may be different than when powered by the commercial utility line. Figure 3 shows the stability of the power line during the X-ray, but the generator set has a greater voltage dip and also attempts to regulate during the X-ray.

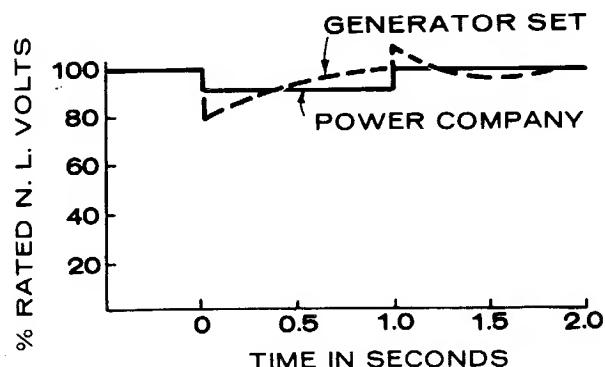


FIGURE 3. VOLTAGE DIP OF GENERATOR SET AND UTILITY POWER

2. Between the time the operator makes the adjustment for the X-ray and takes the X-ray, no large load changes should take place from elevators or air conditioning switching on or off. This is of particular concern in mobile applications where there are usually two large loads, the X-ray equipment and the air conditioner. For these applications, it is recommended the air conditioning be left on continuously and the temperature be controlled by changing the ratio of outside air to cooled air with a small motorized control.

The X-ray machine is designed to operate from the power line. Most have a line voltage compensator, some of which are installer adjustable and others are adjustable by the operator. In applications where the generator set is the only power source, the line voltage compensator can be adjusted for the generator set's voltage dip. For X-ray equipment having been adjusted for power line operation, the

TABLE 11. X-RAY MINIMUM ENGINE AND GENERATOR REQUIREMENTS

X-RAY RATING		PEAK LOAD (KVP x ma x PF**) MIN. ENGINE kW	MIN. kVA RATING* MIN. GENERATOR kVA
ma	kVP		
15	100	1.5	3.8
20	85	1.7	4.3
40	125	5.0	12.5
50	125	6.3	15.8
100	125	12.5	31.3
200	125	25.0	62.5
300	125	37.5	93.8
300	150	45.0	112.0
500	125	62.5	156.0
500	150	75.0	187.0
700	110	77.0	192.0
1200	90	108.0	270.0

* Minimum Generator kVA = $\frac{\text{PEAK LOAD}}{0.4}$

** If power factor is unknown, use 1.0.

generator set must duplicate the voltage dip of the utility power line as close as possible. X-ray engine and generator requirements are shown in Table 11.

Past experience shows whenever the X-ray unit's peak load is approximately 40 percent of the generator's continuous kVA rating, the X-ray pictures will be satisfactory. This results in approximately 6 percent voltage dip on most Onan units. Higher current and voltage settings on the X-ray machine may not be usable if the voltage dip approaches 10 percent.

Sample X-ray problem: The X-ray loads can be calculated by multiplying the kVP by the ma. With 200 ma X-ray, 125 kVP, 0.95 PF, we find:

$$0.2 \text{ amps} \times 125,000 \text{ volts} = 25 \text{ kVA.}$$

$$\text{kW} = \text{kVA} \times 0.95 \text{ PF} = 23.8 \text{ kW.}$$

To find the minimum size continuous kVA generator for this application, divide

$$\frac{25 \text{ kVA}}{40\% \text{ or } 0.4} = 62.5 \text{ kVA.}$$

Generator set selection results in two model choices.

Choice 1: 55.0 EN, full output, single phase.
Allows a miscellaneous load of 31.2 kW (55 kW - 23.8 kW = 31.2 kW).

Choice 2: 55.0KB, full output single phase.
Allows for a 31.2 kW miscellaneous load (55 kW - 23.8 kW = 31.2 kW).

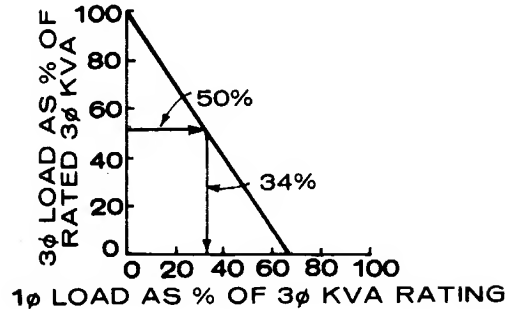
ALLOWABLE SINGLE AND THREE PHASE UNBALANCE

Loads often consist of both three phase and single phase equipment. An easy rule to remember with Onan generator sets is that any combination of single phase and three phase loads is permissible as long as the nameplate line current rating is not exceeded. This rule limits the maximum single-phase load to 58 percent of the generator three-phase rating, but the generator can be loaded to 66 percent of the three-phase rating because the unused winding will dissipate the heat. For allowable combinations of unbalanced loads, see Figure 4.

Example: Determine the single phase load possible for a generator set with a 125 kVA, 100 kW rating and has a 62 kVA, three-phase load. Then calculate:

$$\frac{\text{kVA LOAD}}{\text{kVA GENERATOR RATING}} = \%$$

$$\frac{62 \text{ kVA LOAD}}{125 \text{ kVA GENERATOR RATING}} = 50\%.$$



CAUTION This curve applies only to wye or delta connected three-phase generators when loaded with combinations of symmetrical three phase and line-to-line, single-phase loads.

FIGURE 5. DETERMINING MAXIMUM SINGLE PHASE LOAD WITH A THREE PHASE LOAD

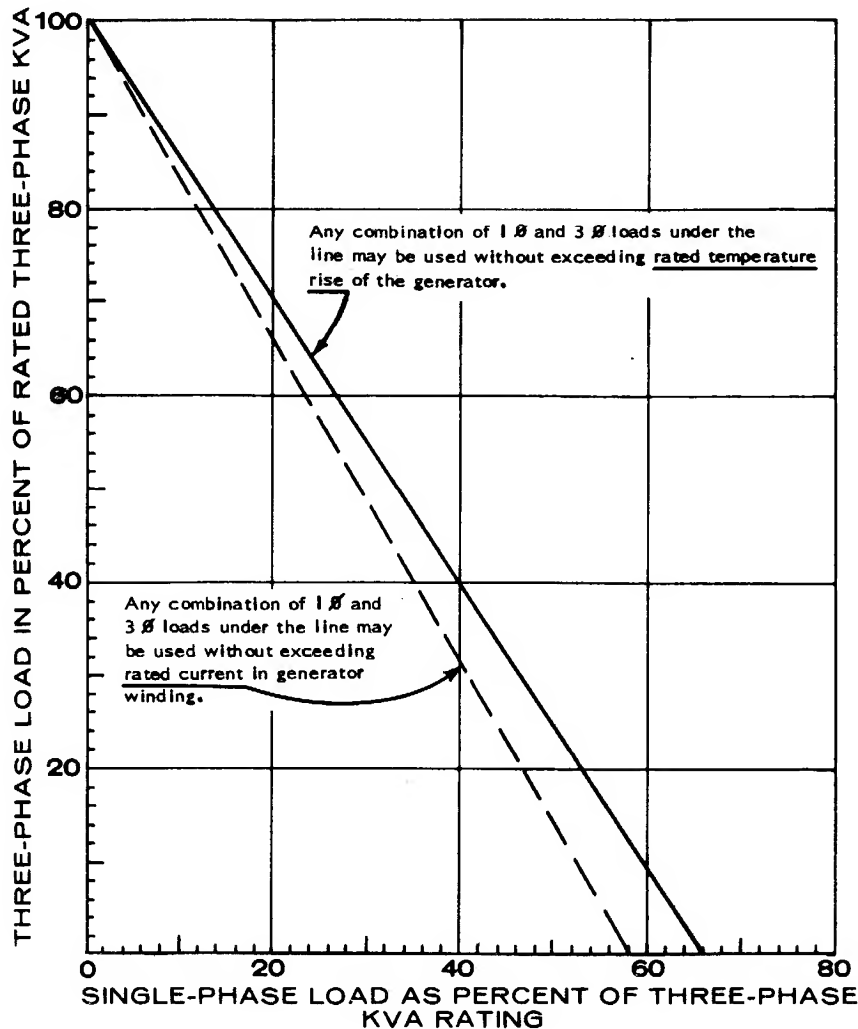


FIGURE 4. ALLOWABLE COMBINATIONS OF UNBALANCED LOADS

The maximum single-phase load allowed according to Figures 4 and 5 is approximately 34 percent of the three phase rating ($125 \text{ kVA} \times 34 \text{ percent} = 42.5 \text{ kVA}$).

The total kVA, $62 \text{ kVA} + 42.5 \text{ kVA} = 104.5 \text{ kVA}$, is less than the 125 kVA rating of the generator set. If the single-phase load could be split into three equal loads, the full rating of the generator set could be used.

CAUTION

When unbalanced loads are connected to a three-phase generator, the phase voltages are no longer balanced. The amount of unbalanced voltage can be greater than 10 percent between phases, depending upon the amount of unbalanced load connected to the generator. Therefore, place any critical load on the same phase as the voltage reference circuit. (L1-L2 as defined in generator set schematic).